Designing an IoT Based Stabilizer for Home Appliances

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A thesis submitted to the Department of Electrical and Electronic Engineering of BRAC University, in partial fulfillment of the requirements for the degree of
Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
BRAC University
September, 2021

Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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Abstract/Executive Summary

A voltage stabilizer is a device that detects and corrects abnormal voltage levels in order to create a sufficiently steady output where the load is attached. The goal of this project is to build and construct an automated high-performance voltage stabilizer that can identify and adjust incorrect voltage levels to provide a sufficiently steady output as well as monitoring the output voltage wirelessly through NodeMCU microcontroller unit and Blynk mobile application. The system is comprised of five interdependent architectural designs: power supply, voltage regulator, monitoring circuit (NodeMCU), and step up transformer, which provides the needed signal when activated by a relay driver to illuminate the bulb. The relay contacts are suitably integrated to the transformer taps to carry out the aforementioned operations in accordance with the directions provided by the BJT (Bipolar Junction Transistor) output. The proposed circuit works well and the results are good. When installed, the relay trips whenever the input voltage exceeds 250 volts, lowering the output voltage to 220 volts and holding it there constantly. When the voltage is fixed at 220 volts, the relay de-energize while pulling the voltage to approximately 240 volts and retaining the difference when the voltage falls further. The preceding operation maintains the appliance's output voltage between 220 volts constantly, with variations ranging from 140 to 250 volts.

Keywords: NodeMCU; Relay Driver; BJT; Power Supply; Step-Up Transformer; Voltage Regulator.

Acknowledgement

First of all, we thank the Almighty for providing us with the wonderful health and well-being that allowed us to finish this thesis paper. We would like to thank and express sincere appreciation to our thesis advisor Dr. A. S. Nazmul Huda, Assistant Professor of the Department of Electrical and Electronic Engineering at BRAC University, for sharing his expertise and for providing guidelines. He convincingly advised and encouraged us to think critically. Without his encouragement and determined help, the completion of this project on time would not have been possible. We would like to dedicate our work and express very profound appreciation to our beloved parents who gave us endless love, continuous mental and financial unfailing support and offered deep insight into the study.

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List of Acronyms

SoC	**System on Chip**
IoT	Internet of Things
BJT	Bipolar Junction Transistor
MCU	Microcontroller Unit
AVR	Automatic Voltage Regulator
AVS	Automatic Voltage Stabilizer
PAVS	Programmable Automatic Voltage Stabilizer
EEPROM	Electrically Erasable Programmable Read-Only Memory
USB	Universal Serial Bus
DIP	Dual In-Line Package

Chapter 1: Introduction

1.1 Motivation

Voltage variations cause the load to fail either temporarily or permanently. Due to the uncontrolled low or higher voltage than the desired voltage necessary for the load, these voltage fluctuations also impair the life span of home equipment. Voltage fluctuations arise as a result of unexpected load changes or power system problems. The use of microprocessor chip technology and power electronic devices in the construction of intelligent AC voltage stabilizers (or automatic voltage regulators (AVR) resulted in a high-quality, steady electric power supply in the case of a considerable and continuous mains voltage deviation. Stabilizers have been found to work with a wide range of devices, including CNC machines, air conditioners, television sets, medical equipment, computers, telecommunication equipment, and so on, and have become an optimized power solution for many electronic appliances that are sensitive to voltage fluctuations. To prevent this uncontrolled voltage variations, we ought to permanently solve this problem by maintaining a straight 220V output always as well as if the voltage output gets higher than the threshold one our method of designing this stabilizer will clip the high voltage down to the threshold value immediately.

1.2 Why Stabilizer?

With a standard voltage supply, known as the nominal operating voltage, all electrical/electronic equipment are designed and constructed to function at peak efficiency. The working range (with optimum efficiency) of an electrical/ electronic device may be limited to 5%, 10%, or more depending on the designed safe operating limit. The Voltage stabilizer ensures that the device receives the desired and stabilized voltage regardless of how much the voltage fluctuates. As a result, a voltage stabilizer is a very efficient solution for anyone who wants to get the best performance and protect their devices from the supply's unpredictable voltage fluctuations, surges, and noise.

Effects of Constant/Recurring Overvoltage on Home Appliances:

- It has the potential to permanently damage the connected device.
- It may cause an unneeded disruption in the load.
- It may cause the cable or device to overheat.
- It may shorten the device's useful life.

Effects of Constant/Recurring Undervoltage on Home Appliances:

- It may cause equipment to malfunction.
- In some cases, the device can take several hours to perform the same function.
- It may impair the device's performance.
- It may cause the device to draw large currents, which may lead to overheating.

1.3 Difference between IoT & regular Stabilizer

(I) Regular Stabilizer:

A regular stabilizer observes the fluctuation from the rated voltages and monitors it. As long as the voltage is below 220V it does not pass current though the device or equipment. While monitoring for a certain time, when it receives a constant voltage from the rated current or supplied current it passes current to the device and equipment that it connected to the voltage stabilizer.

(II) IoT Stabilizer:

It monitors the rated voltages and raises or reduces the rated current to 220V constant output in an IoT-based stabilizer. As a result, the equipment can always run at constant voltage electricity. The reason it is considered IoT is because it will provide and can be controlled wirelessly with the assistance of a Wi-Fi module and can be monitored via a mobile application.

1.4 Literature Review

In order to investigate the various methods used for IoT based stabilizer for our thesis, we had to consider many previous works. Given the sensitivity of varying voltage in terms of increasing the device's efficiency as well as maintaining a filtered, protected and stable power supply feed in order to provide the best performance. As a result, we considered the following literatures:

According to **I. Hamidah et al.** [2] in practice, the alternating current power supply used in electronic devices can change at any time. Electronic devices can suffer significant damage as a result of this. As a result, critical electrical equipment may be damaged. Problems such as power quality, voltage, surge, and brownout can have a significant impact on the industry's negative productivity. Furthermore, this issue causes issues with common electrical equipment such as fans, laptops, coolers, and refrigerators. To address this issue, practitioners typically use voltage stabilizers to secure electronic devices. This paper compares the performance of an existing AVS (Automatic Voltage Stabilizer) with a PAVS (Programmable Automatic Voltage Stabilizer) designed by researchers. To detect problems and automatically alter the entire system, a microcontroller is employed in conjunction with multiple protection devices. This system's circuit is simpler and easier to understand than most control circuits. The PIC IDE programming language was used to simulate circuits and programs.

Also **I. Adabara et al.** [3] research's purpose is to create and implement an automatic high-performance voltage stabilizer that can identify and rectify improper voltage levels in order to generate a suitably steady output. With technical improvements, the implemented gadget has been integrated with an alternate power source (DC Batteries) to avoid power outages; additionally, the invention has been paired with an alarm system to alert the user of the power outage. This project is beneficial since it addresses real-world power issues. Researchers built the device with cutting-edge technology that will eventually replace current ways since the essential components were available at reasonable prices. In comparison to the current invention, the method is less expensive.

Steven et al. [4] explains two of the most significant concerns facing industry today are voltage sags and prolonged under voltages. Voltage sags have the potential to have a considerable negative impact on productivity, which is unavoidable in industrial and commercial settings. Current tap-changing transformers in distribution networks have proven ineffective in fixing line regulation problems. One solution to these problems is to install an ac voltage–voltage converter developed specifically for voltage-sag correction. This system was created to suit the speed and efficiency demands of industrial clients. It uses high-speed insulated gate bipolar transistor switching technology. The simulation findings given in this study showed that the alternating current voltage–voltage converter might be used to correct voltage sag. The efficiency and flexibility of using such a system in power distribution stations was investigated, and it was shown that it might provide a practical solution to current power quality difficulties.

O.V. Statsenko et al. [5] highlights on the issue of power quality in distribution networks has become increasingly critical in recent years. This is mostly due to an increase in the number of electricity consumers who are unable to use existing networks [5]. Network deterioration, on the other hand, frequently leads in outages and poor connection. These causes can cause phase voltages to drop or rise, with considerable variations from nominal values. The operation of household equipment is affected by such a change in supply voltage, and it might lead to their failure. Special devices called voltage stabilizers are employed to prevent such unfavorable outcomes. There are a large variety of alternative voltage regulator circuit solutions available today. One of the easiest techniques is to use a transformer with many series-connected windings with taps. The goal of this work is to look at the characteristics of voltage stabilizers and to outline the needs and methodologies for building control systems for them.

Karimov et al. [6] explains the operation of an optoelectronic voltage relay in a voltage stabilizer for switching the windings of a boost voltage transformer. It was determined that the change in the shape of the output voltage curve is approximately a sinusoid and matches to the experimental results based on the MATLAB R2014a simulation of the proposed optoelectronic contactless voltage stabilizer. While modeling a voltage stabilizer, the properties of the resistor components corresponding to the open or closed state of the semiconductor device at the time of switching the vents do alter. The "input-output" characteristic of voltage fluctuations in rural areas, as well as an assessment of existing voltage stabilizers based on the "quality voltage" theory.

Titovski et al. [7] also tells us that stabilized voltage sources are nearly universally used. Developers choose pulse voltage stabilizers over linear stabilizers when developing such sources since they have clear and substantial advantages over linear stabilizers, such as high efficiency and therefore reduced heat generation, as well as low weight and compact overall dimensions. In pulse stabilizers, using a digital control contour rather than an analog one prevents temperature and time drift of parameters, which is prevalent in analog circuits and is a current research topic. The study offered an analytical model of the digital control contour of a pulse voltage stabilizer. By reducing the effect of errors in analog-to-digital conversion in the output voltage measuring circuit and transitioning to a discrete representation of the pulse duration for controlling the stabilizer power key in a whole number of cycles, the proposed model offers opportunities to improve stabilizer operation.

Thus, we can observe that many various studies provide different pathways to introduce stable and uninterrupted voltage regulation at several stabilizer. This study considers IoT based stabilizer mechanism which aims at merging various methods with a wireless system to monitor & provide a more innovative way of obtaining better stabilization.

1.5 Thesis Outline and Objective

Our objective is to design a system which provides an unhindered output voltage using the IoT based module while maintaining a stable output voltage of 220V in order to obtain an efficient voltage as well as minimum damage done to the battery. Basically, this thesis consists of 5 chapters,

- **Chapter 1** presents an introductory part with motivation, importance of stabilizer, difference between IoT based and regular stabilizer, thesis outline and objective.
- **Chapter 2** provides a comprehensive detail of several component used in this thesis project such as ATMEGA328P microcontroller unit, relay driver, NodeMCU, diodes, capacitors, step up transformer and so on.
- **Chapter 3** comes with simulation which includes schematic diagram of whole IoT system, demonstration of C code used in this project.
- **Chapter 4** deals with the analysis and calculation part of transformer including turns ratio calculation as well as core loss counting.
- **Chapter 5** summarizes our contribution in this project with possible future works

Chapter 2: Details of Components

We have used different types of comments for the project and they are listed below:

- Transformer (Step-Up)
- Relay 12V
- Transistor Array (ULN2003)
- Diode (4007)
- 4148 Signal Diode
- 5V Zener Diode
- Transistor (547)
- Capacitor (50V/220uf)
- Capacitor 50V/100uf
- 50V/10uf
- Programming IC (ATMega8APU)
- LM7805 Voltage Regulator
- Transistor Tip 122
- Resistor (1K)
- Resistor (10K)
- Resistor (33K)
- Resistor (150K)
- 100-ohm 2 Watt
- 7 Segment 3 Channel

- Booster Capacitor
- ATmega328p
- 20*4 LCD Display
- NodeMCU

2.1 Diode

A diode is a semiconductor device that acts as a current switch in one direction only. It allows current to flow freely in one direction while severely restricting current flow in the other. Diodes are also known as rectifiers because they convert alternating current (AC) to pulsating direct current (DC) (DC). The type, voltage, and current capacity of diodes are used to classify them [8]. An anode (positive lead) and a cathode (negative lead) define the polarity of a diode (negative lead). Most diodes allow current to flow when the anode is given a positive voltage. This diagram depicts 2 bias configurations:

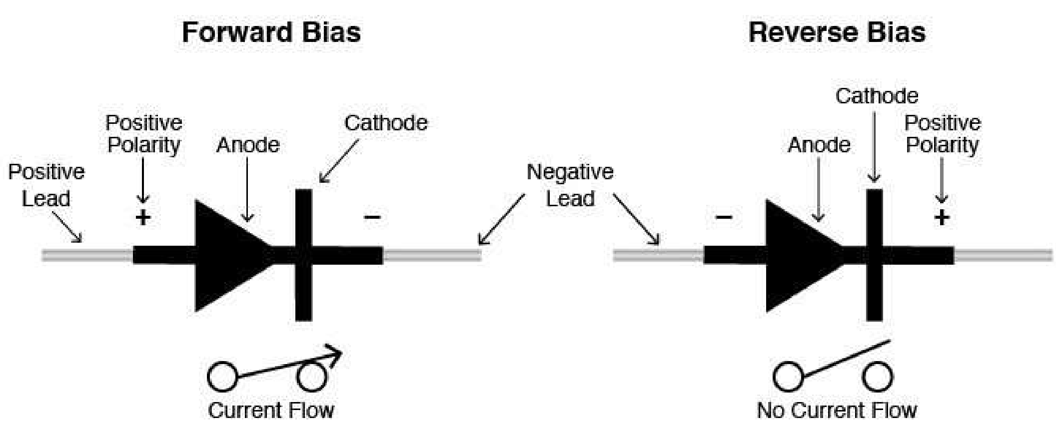

Figure 2.1: Forward Bias and Reverse Bias Diode

A diode is considered to be forward-biased when it allows current to pass through it. When a diode is reverse-biased, it acts as an insulator, blocking the passage of electricity. The arrow in the diode symbol points in the opposite direction of electron flow, which is surprising yet accurate. Engineers invented the sign, and their schematics depict current flowing from the voltage source's positive (+) to negative (-) sides (-). The arrow in semiconductor symbols follows the same convention: it points in the permissible direction of "conventional" flow and away from the allowable direction of electron flow.

2.2 L7805 (35V/1Amp)

The 7805 is a three-terminal linear voltage regulator with a fixed output voltage of 5 volts that may be used in a variety of applications. Texas Instruments, ON Semiconductor, STMicroelectronics, Diodes integrated, Infineon Technologies, and others now produce the 7805 Voltage Regulator IC [9]. They come in a variety of IC packages, including TO-220, SOT-223, TO-263, and TO-3. The TO-220 Package is the most widely utilized of them (it is the one shown in the above image). Some of the important features of the IC are as follows:

- It has a current capacity of 1.5 A. (with heat sink).
- Internal current limiting and thermal shutdown are both available.
- To work properly, it requires a few external components.

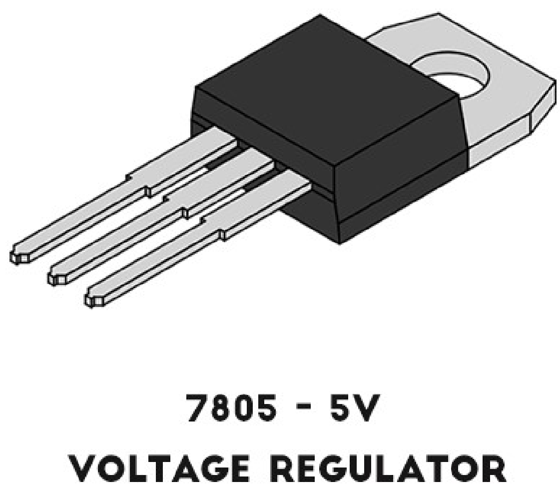

Figure 2.2: Pin Diagram of 7805 Voltage Regulator IC

Basic Circuit of 7805

The fundamental circuit required for the 7805 to work as a full regulator, according to the datasheets, is rather straightforward. In reality, if the input source is an unregulated DC voltage, just two capacitors are required (though they may not be necessary depending on the implementation) [10]. All of the components necessary for a 7805 IC to work properly are shown in the circuit above. Only if the distance between the regulator IC and the power supply filter is very considerable is the 0.22F capacitance near the input necessary. Furthermore, the 0.1F capacitor at the output is optional, although it improves transient responsiveness if used.

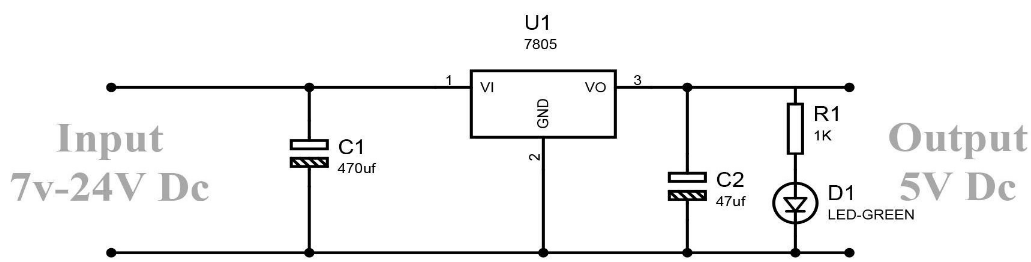

Figure 2.3: Circuit Diagram of 7805 IC

2.3 Relay Driver

Relays have been around for a long time and, while they have been mostly supplanted by solid-state switches, they have special qualities that make them more resilient than solid-state devices and will not be phased out. High current capacity, ESD resistance, and drive circuit isolation are the distinguishing features [11]. There are several methods for driving relays. In preparation for some of the more complicated relay drivers we plan to upload in the future, we have included a few basic relay drivers for our convenience. The output of a microprocessor in a low-power circuit is very low. It is sufficient for an LED to shine, but we will need a Relay (Electromagnetic Switch) to drive a large load, and we will need a relay driver to provide correct voltage or current to a relay. The following are included: Drivers for high and low side toggle switches, bipolar NPN transistors, Darlington transistors, and N-Channel MOSFETs.

Figure 2.4: Relay Driver

Basic Circuit of NPN Relay Switch

A common relay switch circuit has the coil controlled by an NPN transistor switch, TR1, depending on the input voltage level, as illustrated. The transistor is switched off and functions as an open switch when the base voltage is 0 (or negative). In this case, no Collector current flows, and the relay coil is de-energized since relay coils are current devices, and if no current flows into the Base, no current will flow through the relay coil [12]. The current flowing from Base to Emitter (B to E) regulates the bigger relay coil current traveling through the transistor from Collector to Emitter if a sufficiently strong positive current is now delivered to the Base to saturate the NPN transistor.

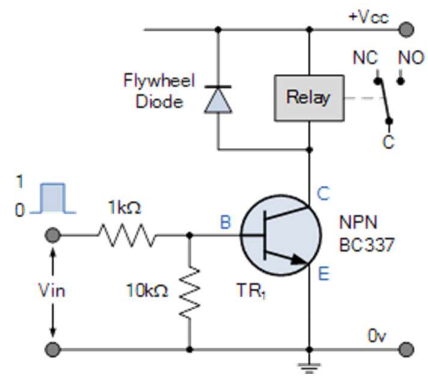

Figure 2.4.1: Relay Switch Circuit Diagram

2.4 Step Up Transformer

The output (secondary) voltage of a step-up transformer is greater than the input (primary) voltage. To keep the input and output power of the system equal, the step-up transformer decreases the output current. Take a look at the step-up transformer in the diagram below [13]. T1 and T2 are the number of turns on the transformer's primary and secondary windings, respectively. E1 and E2 are the voltages, while T1 and T2 are the number of turns on the transformer's primary and secondary windings, respectively.

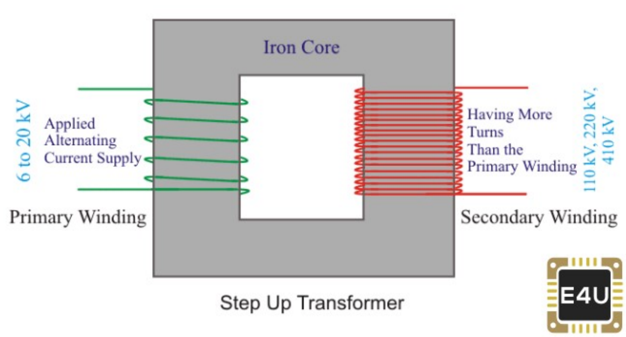

Figure 2.5 Step Up Transformer

T2 > T1 means that the number of turns on the secondary of the transformer is more than the number of turns on the primary. As a result, the voltage turn ratio of the step-up transformer is 1:2. The primary winding of the step-up transformer is made of thick insulated copper wire due to the low magnitude current that passes through it. [14]

Step-up transformers are used in transmission lines to translate the high voltage produced by alternators. The transmission line's power loss is proportional to the square of the current flowing through it.

$$I^2R = \text{Power}$$

The step-up transformer is used to decrease power loss since it has a lower output current. Microwave ovens, X-ray machines, and other equipment employ the step-up transformer to start electrical motors.

2.5 ATMEGA 328P Microcontroller

A thorough introduction to the ATMEGA-328P the ATMEGA-328P is an AVR (Advanced Virtual RISC) microcontroller. It can process data at an 8-bit resolution. The internal flash memory of the ATMEGA-328P is 32KB. [15]

The ATMEGA 328p has 1KB of EEPROM (Electrically Erasable Programmable Read-Only Memory) (EEPROM). This characteristic demonstrates that even if the microcontroller's power source is withdrawn, it can still store data and produce results after being provided with power. Furthermore, the ATMEGA-328P features 2KB of Static Random-Access Memory (SRAM). Other qualities will be discussed further below. The ATMEGA 328P has a variety of features that make it the most popular gadget on the market today.

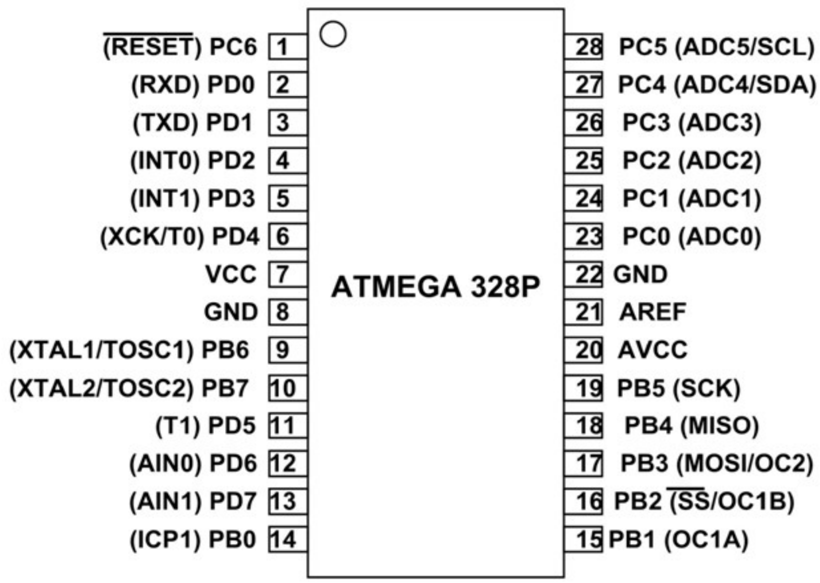

Figure 2.6: Pin Diagram of ATMEGA-328P

2.6 ATMEGA8A-PU Microcontroller

Microchip's AVR® ATmega8A is a low-power 8-bit CMOS microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8A achieves throughputs approaching 1 MIPS per MHz, allowing the system designer to balance power consumption and processing performance [16]. 32 x 8 General Purpose Working Registers – Advanced RISC Architecture – 130 Powerful Instructions – Most Single-Clock Cycle Execution

- 32 x 8 General Purpose Working Registers

- Completely Static Operation

- At 16MHz, throughput can reach up to 16MIPS.

- High Endurance - On-chip 2-cycle Multiplier Memory portions that are non-volatile

- 8KBytes of self-programmable flash memory in-system

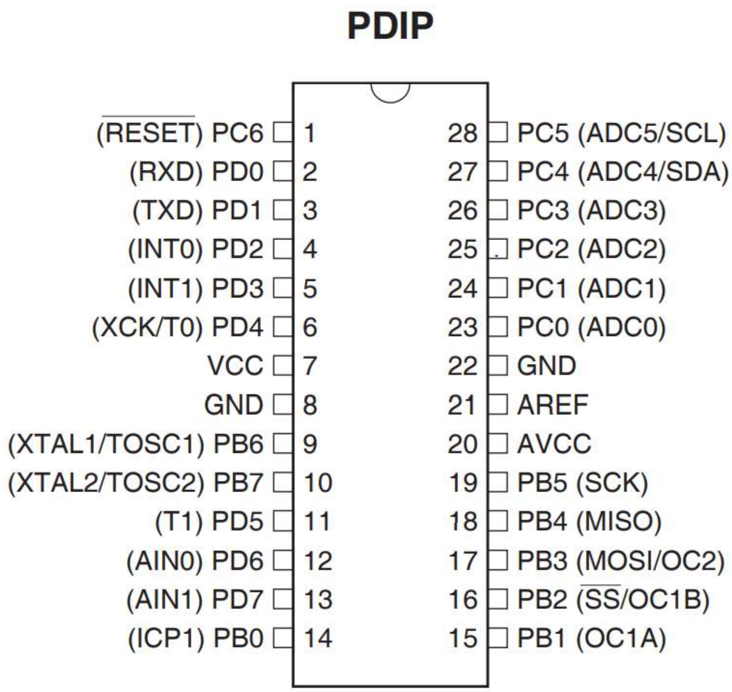

Figure: 2.7 Pin Diagram of ATMEGA 8A-PU Microcontroller

2.7 NodeMCU

NodeMCU is a firmware for the ESP8266 created with the C programming language, the Espressif NON-OS SDK, and the Lua scripting language. The firmware is written in the Lua programming language. The firmware is based on the eLua project [17] and was created with the Espressif Non-OS SDK for ESP8266. It heavily relies on free source programs like lua-cjson and SPIFFS. Support for the 32-bit ESP32 is also included. For prototyping, a dual in-line package (DIP) circuit board that combines a USB controller with a smaller surface-mounted board containing the MCU and antenna is often utilized. The use of the DIP format makes prototyping on breadboards a breeze. The design was based on the ESP8266's ESP-12 module, which is a Wi-Fi SoC with a Tensilica Xtensa LX106 core that is extensively used in IoT applications.

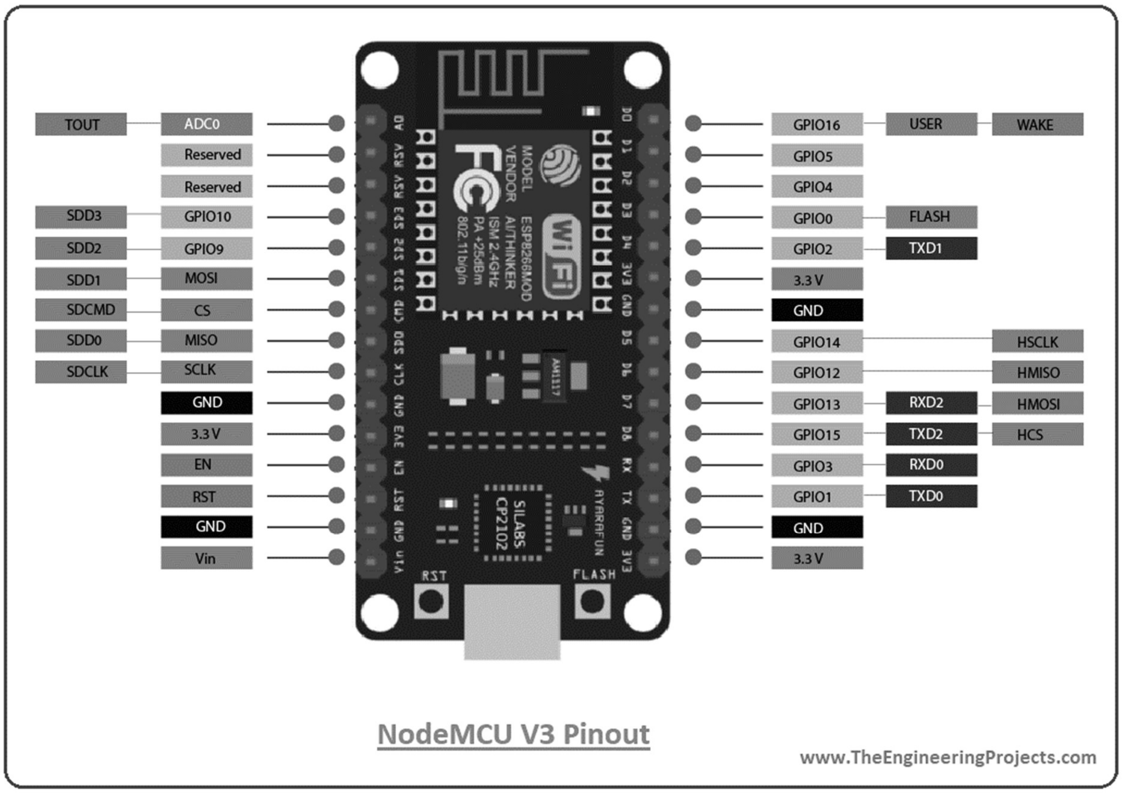

Figure 2.8: NodeMCU

It became necessary to modify the Arduino IDE as Arduino.cc began developing new MCU boards based on non-AVR processors, such as the ARM/SAM MCU used in the Arduino Due, so that it would be relatively easy to change the IDE to support alternate toolchains, allowing Arduino C/C++ to be compiled for these new processors. The SAM Core and the Board Manager have been introduced. A "core" is a set of software components required by the

Arduino IDE and the Board Manager to produce an Arduino C/C++ source file for the target MCU's machine language. The "ESP8266 Core for the Arduino IDE" was produced by several ESP8266 fans as an Arduino core for the ESP8266 WiFi SoC. This has grown to be the most popular software development platform for ESP8266-based modules and development boards, including NodeMCUs. [18]

2.8 LCD20X4 - 20 x 4 Character LCD Display

This 20x4 Character LCD Display includes the RW1063 controller IC, which has options for 6800, 4-line SPI, or I2C interfaces.

The WH 2004A and WH2004B character LCD modules have the same AA size and pin assignment as the WH2004G 20x4 LCD Display, however they have a smaller outline and VA size.

Features:

- 20 Characters x 4 Lines
- 5 x 8 Dots with Cursor
- Built in Controller (HD44780 or equivalent)
- +5V Power Supply
- 1/16 Duty Circle
- RoHS Compliant

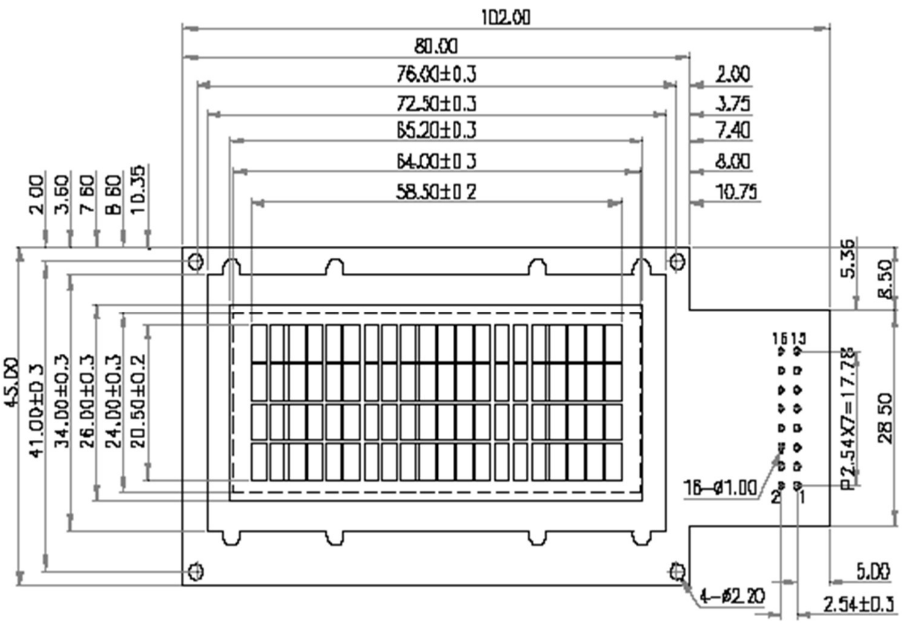

Fig. LCD20X4 - 20 x 4 Character LCD Display

It is used to show LCD displays, digitizer installation, and maintenance operations. With an LCD display, it is simple and convenient to read. LCD displays, which are commonly used in industrial control systems, may be readily switched off. The LCD display is clear, and the screen on any gadget is easy to see. The LCD display, digitizer, and LCD displays are all combined into one unit. This LCD display module includes a huge screen that may be used to monitor the operation of numerous parameters.

Chapter 3: Design and Simulation

3.1 Introduction

In this chapter, we will go over the design and modeling of an IoT-based stabilizer. Here, we will attempt to provide the circuit diagram as well as the actual image of the project that has been developed for the specific project that has been completed.

3.2 Designing of The Stabilizer

In this section, we will attempt to demonstrate the design technique and details.

3.3 Power Supply

A power supply is a component that provides power to one or more electric loads in a circuit. The power supply's job is to convert AC to DC so that machines may run their components properly. The product of voltage and current determines the power supply.

We will only discuss AC-DC Power Supplies because we utilized an AC to DC Power Supply.

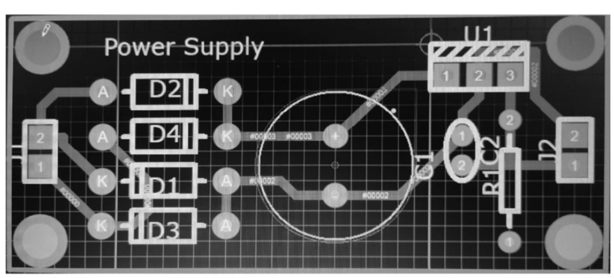

Figure 3.1 Power Supply

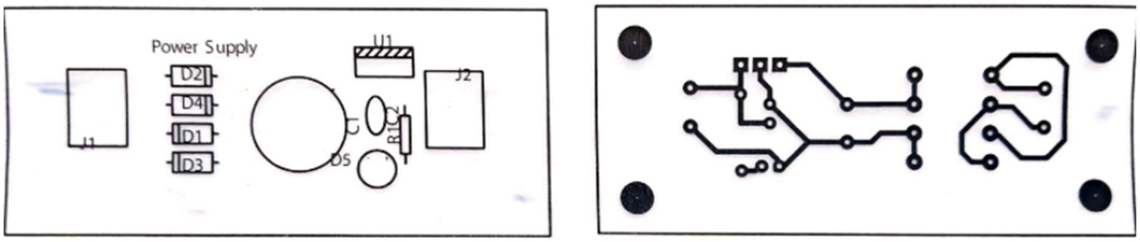

Figure 3.1 Power Supply

AC mains electricity is used to power DC power supplies. In such a power supply, a transformer will be needed to convert the input voltage to a higher or lower AC voltage. A rectifier converts the transformer output voltage to a fluctuating DC voltage, which is then passed through an electronic filter to create an unregulated DC voltage. [19]

The filter eliminates the vast majority of AC voltage fluctuations, but not all of them; the residual AC voltage is referred to as ripple. The amount of filtering needed by a power supply is governed by the ripple tolerance of the electric load. High ripple is permitted in some applications; therefore, no filtering is necessary.

3.4 Schematic Diagram IoT Part

In this part we have used 2 most important components of this project which are; ATMega328p and NodeMCU. The ATMega328p is connected with 3 relays specially for this project to control 3 loads [20]. However, in future we can add more relays to control more loads. The ATmega328p can receive signals from the NodeMCU through WIFI and we can control the loads with it wirelessly.

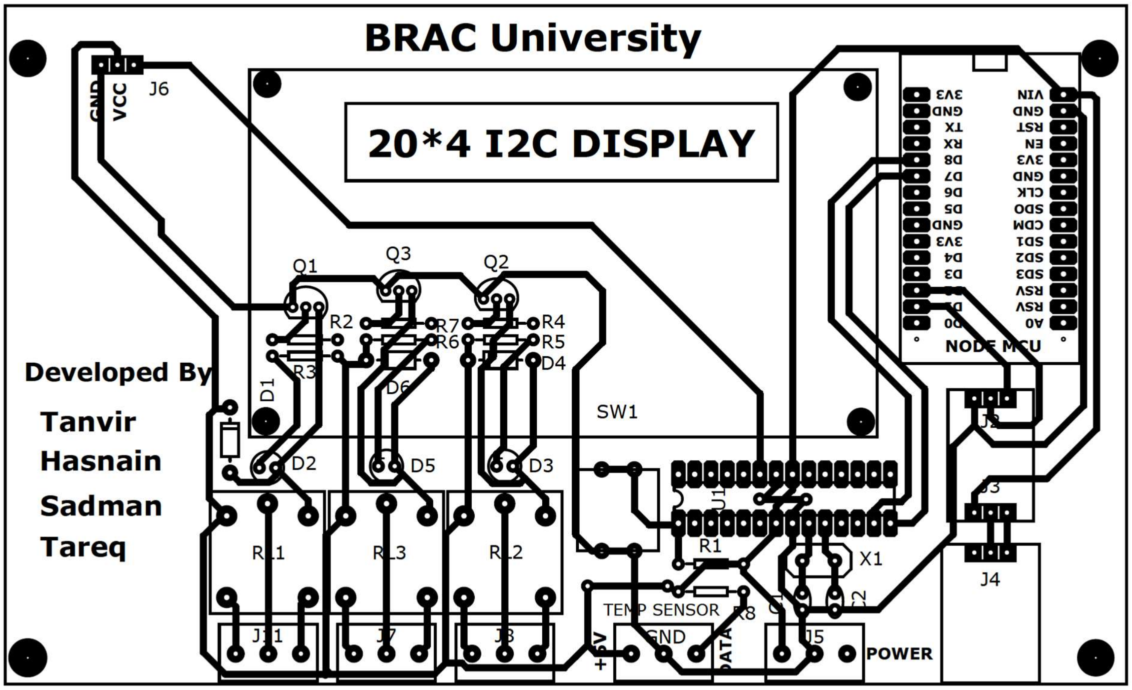

Figure: 3.2 IoT Schematic Diagram

Moreover, we can use the app "Blynk" which is available to download on Play store to monitor the loads and the voltage fluctuations that is being handled by our stabilizer. There is a 20*4 LCD panel which can show the readings of the total voltage draw and usages. We have used a "Reset" button so that if something is out of control or the readings have any inconsistency then we can easily reset the device to start over everything and show use new readings.

3.5 Physical Image of the IoT Part of the stabilizer

This is an actual image of the IoT section of our project. In this part the components are easily visible to understand.

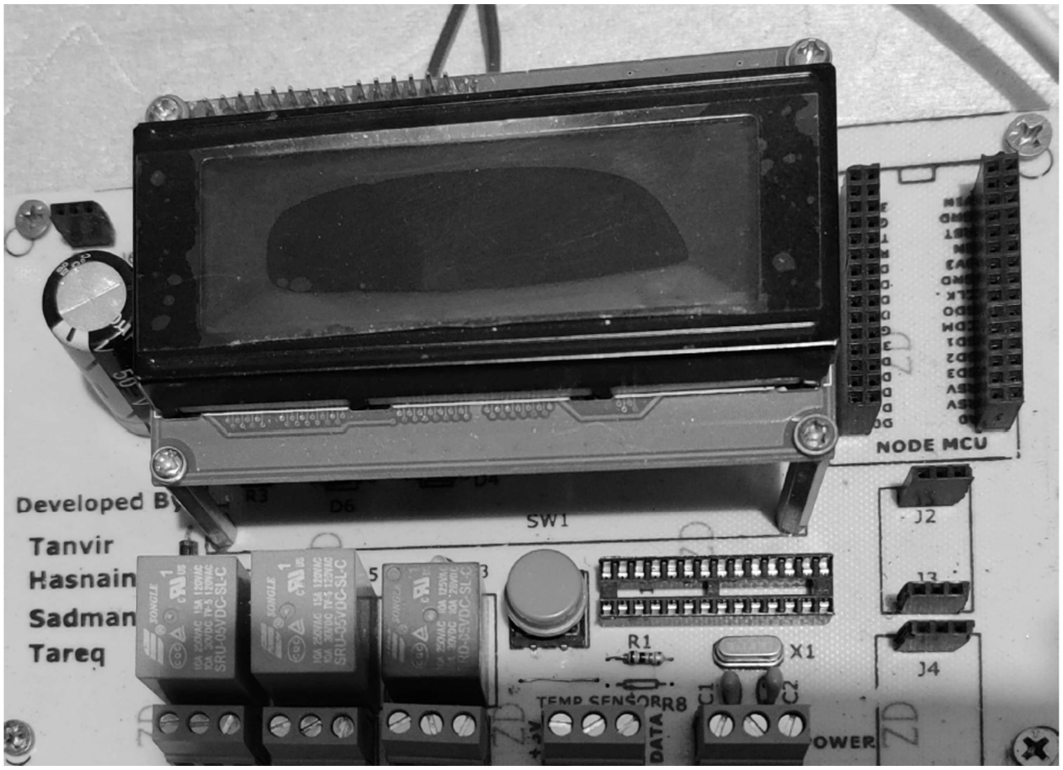

Figure 3.3 Connection of IoT Diagram

As of now, our project can only handle three loads. More relays, on the other hand, can be utilized to control numerous loads.

3.6 Circuit Diagram for The Voltage Tapping Function

In this part we will discuss about the voltage tapping. In the fig. below it shows the circuit diagram for the voltage tapping that has been used for this project. We have used 5 relays to tap the voltages accordingly, tapping voltages are set as; 150V, 180V, 210V, 240V, 270V. Each of the tap has 30V voltage differences. Each time when the specific voltage is being monitored only one voltage tapping relay will be activated to tap the voltage to the specific connection to the transformer. After being tapped, the transformer will step up the input voltage to 220V if the input voltage is less than 220V and deliver it to the loads.

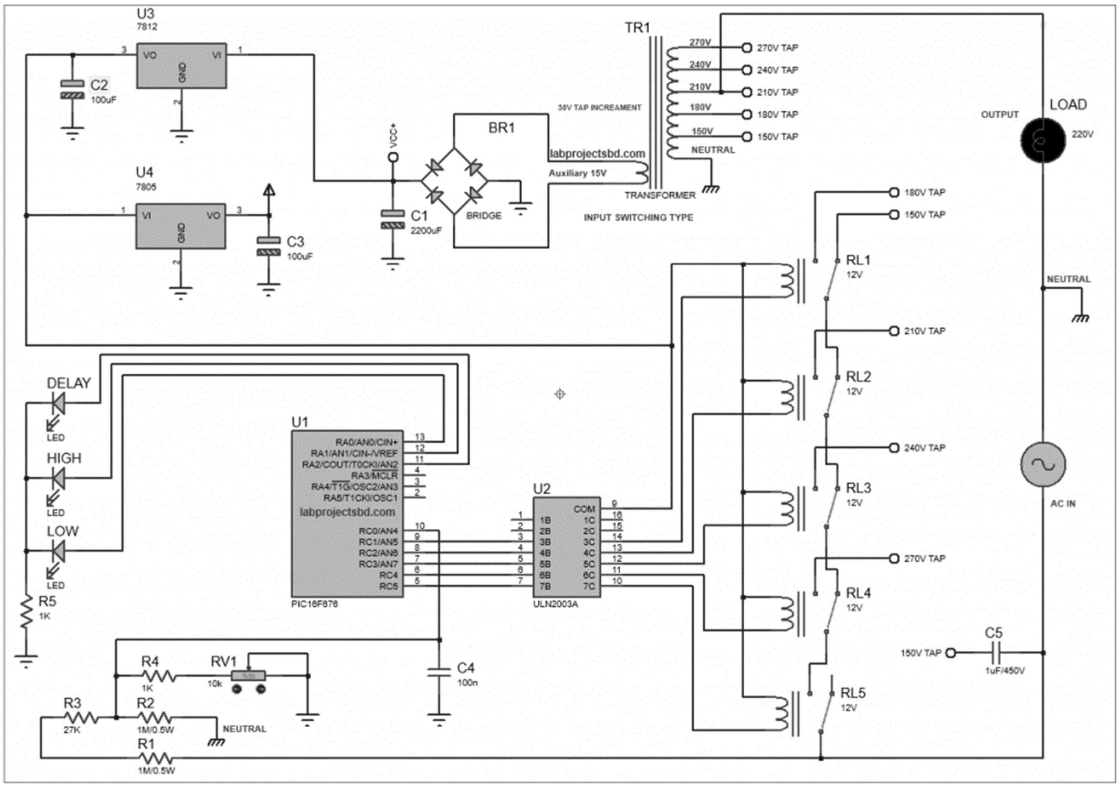

Figure: 3.2.4 Connection of Voltage Tapping

The voltage limit for our stabilizer is from 150-270V. If the voltage is below 150V or above 270V then the system will not work properly.

3.7 Physical Image of The Voltage Tapping Function

In this section we have showed the circuit of the voltage tapping where 5 relays are used to tap voltages to the transformer.

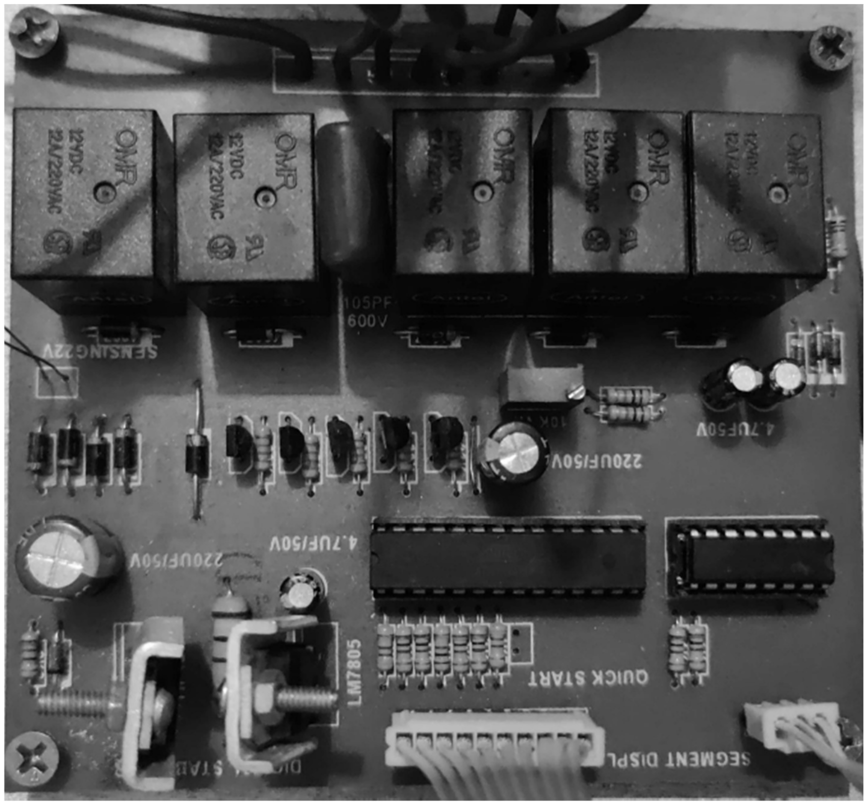

Figure: 3.5 Five Relay Voltage Tapping Function

Here, we have used one extra booster capacitor among the relays so that there is no power overflow to the main circuit board.

3.8 Overall Design Image of The Project

We had to utilize one external Auto Transformer or VARIAC transformer to test the project. As a result, we may provide varying voltage levels to the stabilizer. We would not be able to evaluate the stabilizer's ability to produce 220V continuously in all voltage fluctuation circumstances otherwise.

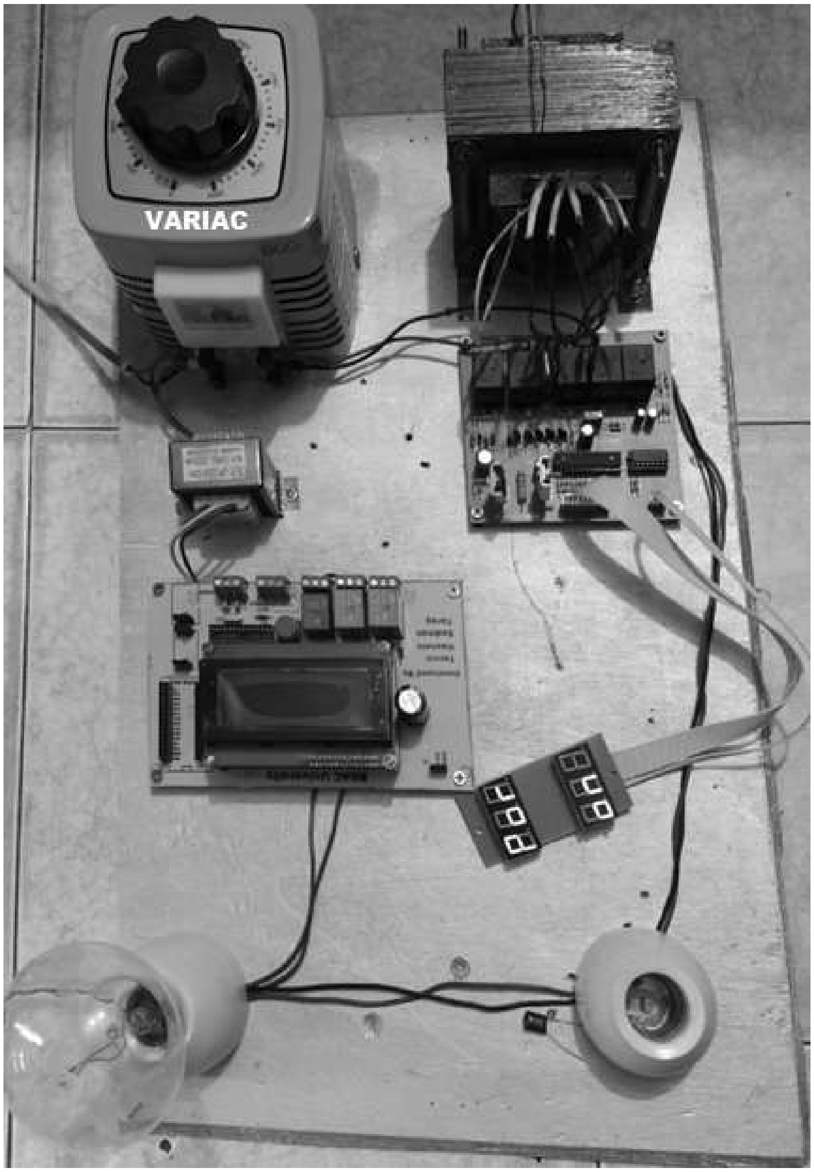

Figure 3.6 Auto Transformer

The VARIAC transformer, on the other hand, has nothing to do with the stabilizer.

3.9 Code Explanation

Coding the ATMega328P to tap the voltages. Here, we explain the code that has been used for the IoT part of the microprocessor. When 150V tap is connected the microprocessor will give signal to the relay5. Here, by "relay5 = 1" is set to be activated whereas rest of the relay values will be 0 so that other relays do not interfere with other voltage tap.

```
if(gap1)
    {
      relay1 = 0;// 150V Tap connected
      relay2 = 0;
      relay3 = 0;
      relay4 = 0;
      relay5 = 1;//injection on
    }
```

Similarly, when the line voltage is greater than 172 and also at the same time less than 204, relay1 and relay5 will be activated to tap the voltage to 220V accordingly.

```
}
      else if(line_voltage>172 && line_voltage<204)
      {
        relay1 = 1;// 180V Tap connected
        relay2 = 0;
        relay3 = 0;
        relay4 = 0;
        relay5 = 1;//injection on
        gap2 = 1;
        gap1 = 0;
        gap3 = 0;
```

Overall code is given below,

```
#define     relay1          RC1_bit
#define     relay2          RC2_bit
#define     relay3          RC3_bit
#define     relay4          RC4_bit
#define     relay5          RC5_bit
#define     delay_led       RA2_bit
#define     high_led        RA1_bit
#define     low_led         RA0_bit
unsigned int line_voltage=0,max_point=0,temp=0;
int i=0,k=0;
bit gap1,gap2,gap3,gap4,gap5;
void main()
{
  TRISA=0x00;//all output
  TRISC=0x01;//all out except RC0_bit
  ANSEL = 0b00010000;//AN4 active
  CMCON=0x07;//comparator off
  ADCON1=0x10;//Fosc/8 speed

  top:
  PORTA = 0x00;//clear port
  PORTC = 0x00;//clear port
  delay_led = 1;
  Delay_ms(180000);//3min delay = 180000;
  delay_led = 0;

  while(1)
  {

     //read input voltage
     line_voltage = 0;
     max_point=0;
     temp=0;
     ADCON0 = 0x11; //AN4
     for(i=0;i<5;i++)
     {
         for(k=0;k<500;k++)
         {
            if(temp=ADC_Read(4),temp>max_point)
            {
               max_point = temp;
               Delay_us(1);
            }
         }
         line_voltage+=max_point*37/10;
```

```
}
line_voltage/=5; //get average value


if(line_voltage<145 || line_voltage>305)
{
    relay5 = 0;
    if(line_voltage<145)low_led = 1;
    else if(line_voltage>305)high_led = 1;
    Delay_ms(10000);//wait 10sec
    goto top;
}
else
{
    if(line_voltage>145 && line_voltage<170)
    {
        relay1 = 0;// 150V Tap connected
        relay2 = 0;
        relay3 = 0;
        relay4 = 0;
        relay5 = 1;//injection on
        gap1 = 1;
        gap2 = 0;
    }
    else if(line_voltage>=170 && line_voltage<=172)
    {
        if(gap1)
        {
          relay1 = 0;// 150V Tap connected
          relay2 = 0;
          relay3 = 0;
          relay4 = 0;
          relay5 = 1;//injection on
        }
        if(gap2)
        {
          relay1 = 1;// 180V Tap connected
          relay2 = 0;
          relay3 = 0;
          relay4 = 0;
          relay5 = 1;//injection on
        }
    }
    else if(line_voltage>172 && line_voltage<204)
    {
```

```
{
    relay1 = 1;// 180V Tap connected
    relay2 = 0;
    relay3 = 0;
    relay4 = 0;
    relay5 = 1;//injection on
    gap2 = 1;
    gap1 = 0;
    gap3 = 0;
}
else if(line_voltage>=204 && line_voltage<=206)
{
    if(gap2)
    {
        relay1 = 1;// 180V Tap connected
        relay2 = 0;
        relay3 = 0;
        relay4 = 0;
        relay5 = 1;//injection on
    }
    if(gap3)
    {
        relay1 = 0;
        relay2 = 1;// 210V Tap connected
        relay3 = 0;
        relay4 = 0;
        relay5 = 1;//injection on
    }
}
else if(line_voltage>206 && line_voltage<238)
{
    relay1 = 0;
    relay2 = 1;// 210V Tap connected
    relay3 = 0;
    relay4 = 0;
    relay5 = 1;//injection on
    gap3 = 1;
    gap4 = 0;
    gap2 = 0;
}
```

```
else if(line_voltage>=238 && line_voltage<=240)
{
    if(gap3)
    {
        relay1 = 0;
        relay2 = 1;// 210V Tap connected
        relay3 = 0;
        relay4 = 0;
        relay5 = 1;//injection on
    }
    if(gap4)
    {
        relay1 = 0;
        relay2 = 0;
        relay3 = 1;// 240V Tap connected
        relay4 = 0;
        relay5 = 1;//injection on
    }
}
else if(line_voltage>240 && line_voltage<270)
{
    relay1 = 0;
    relay2 = 0;
    relay3 = 1;// 240V Tap connected
    relay4 = 0;
    relay5 = 1;//injection on
    gap3 = 0;
    gap4 = 1;
    gap2 = 0;
}
else if(line_voltage>=270 && line_voltage<=272)
{
    if(gap4)
    {
        relay1 = 0;
        relay2 = 0;
        relay3 = 1;// 240V Tap connected
        relay4 = 0;
        relay5 = 1;//injection on
    }
    if(gap5)
    {
```

```
        relay1 = 0;
        relay2 = 0;
        relay3 = 0;
        relay4 = 1;//270V Tap connected
        relay5 = 1;//injection on
    }
}
else if(line_voltage>272 && line_voltage<305)
{
    relay1 = 0;
    relay2 = 0;
    relay3 = 0;
    relay4 = 1;// 270V Tap connected
    relay5 = 1;//injection on
    gap4 = 0;
    gap5 = 1;
}
}
```

Finally, when the line voltage exceeds 270V, relays 4 and 5 are engaged. At such moment, a 270V tap relay will be employed.

Chapter 4: Result and Analysis

4.1 Introduction

In this chapter, we present our suggested technique together with the transformer that is being utilized for this project and that we had to create expressly for it. For example, depending on the voltage measurement, our transformer has a varying turn ratio. It contains 5 relays linked to 5 distinct voltage switching options. According to the voltage that the CPU receives. The microprocessor is linked to five separate relays. Furthermore, the relays are linked by independent voltage triggering wires. As seen in the figure.

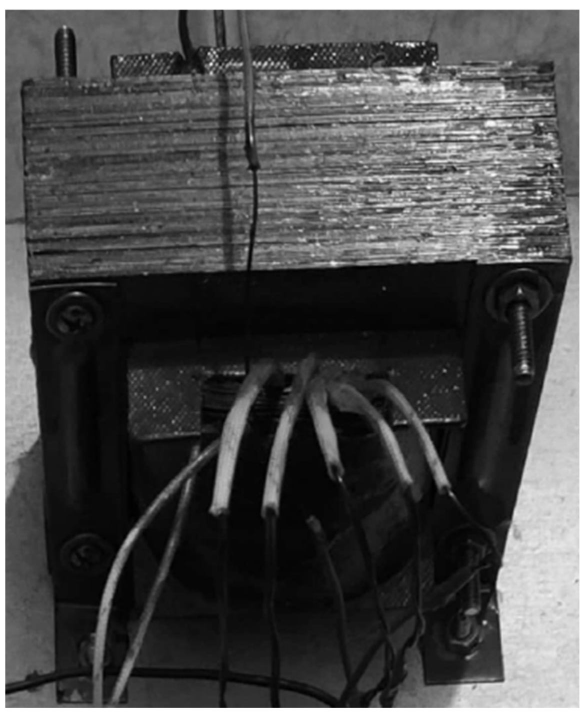

Figure 4.1: Transformer

Specific voltage triggers specific relays thus the transformer gets the information to increase to the voltage or decrease accordingly to maintain constant 220V to the load.

4.2 Designing the Transformer

Thousands of ready-to-use off-the-shelf transformers are available for use in electronic and electrical circuits. When the right item isn't available, we may wish to consider building a bespoke transformer to match our unique requirements.

However, before we can begin designing a transformer, we must first decide a few things. The input voltage(s) and frequency, as well as the output voltage(s) and current, are all included (s). Other physical and electrical criteria to consider include available mounting space, mounting type, isolation needs, leakage currents, and so on.

4.3 Selecting the Core

The initial step is to decide which core will be used in the design. Speak with a core manufacturer to learn more about the specific characteristics and power handling capabilities of each kind and size of core. However, here's a good place to start:

• When less than 400 Hz, a silicon steel lamination is used.

• At 400 to 2000 Hz, consider a tape-wound or nickel-alloy core.

• Above 2000 Hz, look at ferrite.

Basic Design Formulas :

1) N(p)= (Vx10^8) / (4.44 BAf K) sine wave

2) N(p) = (V x 10^8) / (4 BAf K) square wave

3) N(s)=V(s)/V(p) x N(p)

4) I(p)=(VA(s) + losses) / V(p)

5) I(s) = P(out) / V(out)

6) Open circuit voltage (Voc) = N(s)/N(p) x V(p)

7) Loaded voltage (Vld) = Voc- [IR (sec) + (IR (pri) x (N(s)/N(p))]

8) Temp rise (T(C)) = (losses/ (0.008 x surface area))

N(p) = Primary turns

N(s) = Secondary turns

B = Flux density in gauss

A = Core area in centimeters squared

f = Frequency

K = Stacking factor

L = Inductance

A(l) = Inductance per turn squared for a given core

4.4 Windings and Wire

The primary winding current and wire size must be determined. The primary current is equal to the total output power + transformer power losses divided by the primary voltage. We start with a 10% increase in input power, assuming a 90% efficient transformer, to account for power losses. A transformer with a 12-V, 2-A output at 120 V input, for example, would be:

12V x 2A = 24VA; 24VA x 1.10 (110%) = 26.4 VA where the main winding is required; 26.4 VA/120 V = 0.22 A in the first winding

The next step is disputed and liable to change depending on the transformer's characteristics: We generally start with a wire gauge of about 500 circular mills (cm) per amp when determining the initial wire gauge. For tiny transformers, this value may be lower, and for large power transformers, it may be greater; the designer must choose. We'll start with a 29-gauge wire (127.7cm) for the main, based on the prior example of 0.22 A x 500cm/A = 110cm.

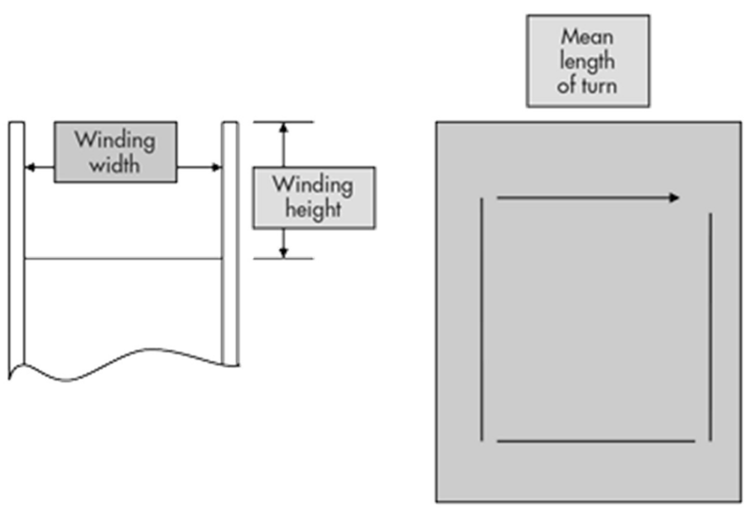

Figure 4.2: Winding and Wire

In the realm of transformers, it's all about "ratios." The primary-to-secondary ratio, input-to-output ratio, and turns ratio of any particular transformer will all be the same as its voltage ratio. In other terms, for a transformer, "turns ratio = voltage ratio." The number of wires that spin on a winding is frequently irrelevant; what matters is the turns ratio, which is expressed as:

$$\frac{Np}{Ns} = \frac{Vp}{Vs} = n = Turns\ Ration$$

Let’s assume a perfect transformer and the following phase angles: $\Phi_P \equiv \Phi_S$

It's important to remember that the order in which the numbers are written when expressing a transformer's turns ratio value is crucial, since the turns ratio 3:1 conveys a completely different transformer relationship and output voltage than the turns ratio 1:3.

A voltage transformer's primary coil has 1500 turns of wire and its secondary coil has 500 turns of wire. So, transformer's turns ratio (TR) will be:

$$T.R. = \frac{Np}{Ns} = \frac{Primary\ Coils}{Secondary\ Coils} = \frac{3}{1} = 3:1$$

This 3:1 (3-to-1) ratio simply means that each secondary winding has three primary windings. When the ratio moves from a larger number on the left to a lower number on the right, the main voltage is stepped down in value.

We had to count the loss and compute the numbers to utilize the amount of turns of wires needed for this specific transformer since we had to deal with varied levels of voltage that were to be tapped by the transformer. And, as a consequence, we were able to obtain results in which the voltage tapping provided precise values to provide 220V constant value to the loads.

4.5 Conclusion

To summarize, a transformer shifts the voltage (or current) on its input winding to a different value on its output winding using a magnetic field. The magnetic flux created by the voltages and currents flowing in the main coil winding induces an EMF in the secondary coil, according to Faraday's concept of "mutual induction".

The primary winding of the transformer is connected to a sinusoidal AC power supply. The load is powered by the secondary winding. As previously stated, a transformer can be operated in reverse with the supply connected to the secondary winding as long as the voltage and current specifications are followed.

Chapter 5: Conclusion and Future Works

5.1 Conclusion

IoT-based stabilizers can be constructed using a variety of methodologies, each with its own set of restrictions. The standard voltage regulator technique, which is nearly universally employed in commercial stabilizers is effective but not so efficient in today's world. Many articles have attempted various design strategies for more efficient stability. In this research, we developed an effective strategy for minimizing volatility. The IoT-based method is used here which combines the concept of a microcontroller-based technology along with wireless monitoring through mobile application.

A literature study was undertaken which examined various modeling alternatives as well as past research design. According to the literature study, one of the difficulties with this sort of research is the large disparities between the various types of approaches. According to a survey of microcontroller-based publications, faster efficiency could be attained by properly managing the input voltage.

The goal of this thesis was to examine the impacts of relay switching mechanisms using Proteus, which was incorporated in the model to correctly portray the microcontroller unit in order to enhance efficiency, and a significant difference between traditional and IoT-based models was identified.

This research has generated some useful discoveries in an IoT-based paradigm. Two alternative methodologies are offered here, and the results were much visible when it was connected with the microcontroller unit and thus monitoring via a wireless module, and curiously, whatever the input voltage is supplied, it will always be at 220V. When the voltage is fixed at 220 volts, the relay de-energizes while pulling the voltage to around 240 volts and retaining the difference if the voltage drops further.

Therefore, we can conclude that using a microcontroller-based method is the most optimal and least harmful method to optimally run the stabilizer while maintaining an optimal temperature at the output part with constant 220 volts reading.

5.2 Future works

This project is not restricted to only three loads and five voltage-determining relays, as well as a single remotely controlled application; more work may be done to construct this stabilizer to manage more loads with more precise voltage monitoring and more remote access possibilities. For various loads, we may configure different voltage levels to be delivered to the loads. As a result, we can adjust the transformer's lifespan, allowing it to run for a longer amount of time.

Furthermore, various auto sensors, such as temperature sensors and voltage up-down fluctuation sensors, may be used to alert us when the device is having difficulty distributing consistent 220V, allowing us to solve the issues immediately.

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